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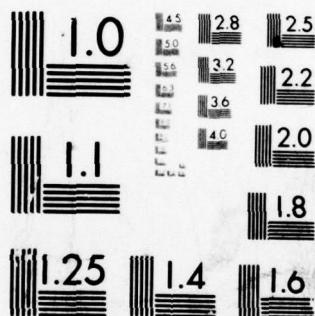
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## REPORT 78-20

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Measurement and identification of aerosols  
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## 20. Abstract (cont'd)

mean concentration was calculated to be 87 particles  $\text{cm}^{-3}$ . The aerosol particles in the maritime air were identified by electron microscopy and selected area electron diffraction analysis. About 20% of the aerosol particles were identified, and 80% of the particles were too small for electron diffraction analysis. Sea salt particles constituted 2% of the total, and clay minerals 3%; these particles were considered to be of natural origin. Solid combustion by-products such as coagulated carbon particles and flyash particles constituted 16%. Despite the comparative remoteness of the sampling site, the measurements indicate that many anthropogenic aerosols were found using an electron microscope.

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## PREFACE

This report was prepared by Dr. Motoi Kumai, Research Physicist, of the Physical Sciences Branch, Research Division, U.S. Army Cold Regions Research and Engineering Laboratory.

The work covered by this report was conducted under DA Project 4A161102AT24, *Research in Snow, Ice and Frozen Ground*, Scientific Area 01, *Properties of Cold Regions Materials*, Work Unit 003, *Microstructure of Cold Regions Materials*.

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# MEASUREMENT AND IDENTIFICATION OF AEROSOLS COLLECTED NEAR BARROW, ALASKA

Motoi Kumai

## INTRODUCTION

The areal concentration, spatial distribution, and identification of aerosols have been studied by many workers. In a study by Farlow et al. (1977), stratospheric aerosols were collected to determine the physical state of the particles and the nature of included undissolved granules. Cattell et al. (1977) collected aerosol particles from the ground to 3200 m near Tasmania, Australia, and determined the chemical compositions by the spot test technique. Urban effects on condensation nuclei and ice nuclei were studied near St. Louis, Missouri, by Braham and Spyers-Duran (1974). Condensation nuclei of fog droplets in Barrow, Alaska, were identified by transmission electron microscopy and electron diffraction analysis (Kumai 1965). Concentrations of cloud condensation nuclei, sodium-containing particles, ice nuclei, and aerosol light scattering coefficients were measured near Barrow, Alaska, by Radke et al. (1976). The background levels of aerosols or natural concentrations are not yet established in the field of atmospheric sciences.

This report describes results of the observation and identification of aerosols collected near Barrow, Alaska, using transmission electron microscopy and electron diffraction analysis.

## SAMPLE COLLECTION

On clear days, aerosols were collected on electron microscope grids covered with collodion film at the arctic seacoast near Barrow,

Alaska, in June 1975. The arctic seacoast was selected as a location with a low level of aerosols. The coast was covered with pack ice during sample collection, and open sea water was apparent offshore. The aerosols were collected from maritime air to avoid local air pollution caused by electric power plants and vehicular traffic. Concentrations of Aitken nuclei were measured using a modified Nolan-Pollack small-particle detector.

The site of aerosol collection was 3 km northeast of the Naval Arctic Research Laboratory. The prevailing wind was northwest, and there was no human activity between the site and the Arctic Ocean (Fig. 1). Power and heat for the laboratory were provided mainly by natural gas. Garbage burning was not observed during the sampling times, although it is sometimes a local source of pollution. The sea ice and tundra surfaces were not significant sources of aerosols. Thus, the site was considered to be almost ideal for measurement of near ground level aerosols in maritime air from the Arctic Ocean. The height of the sampling was about 2 m from the ground. Some aerosol sampling was done in the vicinity of the Naval Arctic Research Laboratory for comparison.

## RESULTS

### Aitken nuclei

Measurements of aerosol concentration in the Barrow area were made with a modified Nolan-Pollack small-particle detector. The detector has a range of 50 to  $10^6$  particles  $\text{cm}^{-3}$  for particles with a diameter greater than  $2 \times 10^{-3}$   $\mu\text{m}$ .



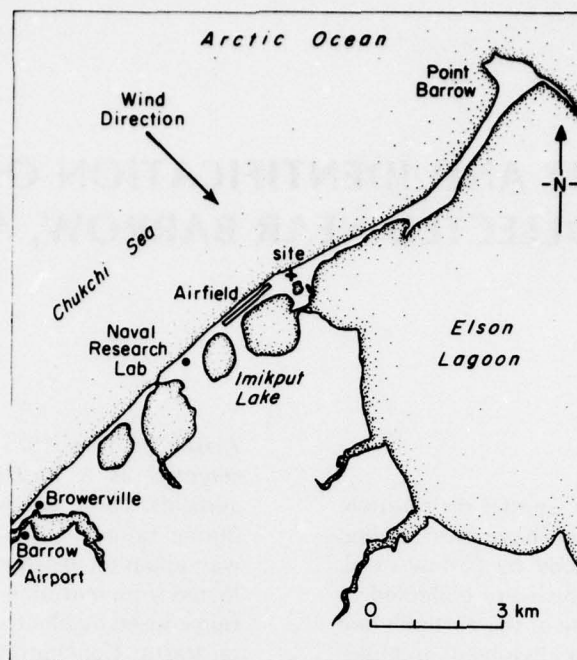


Figure 1. Location of the sample collection site near Barrow, Alaska.

Around the Naval Arctic Research Laboratory, higher concentrations of Aitken nuclei were measured. The local sources of Aitken nuclei were exhausts from vehicle engines, home heating systems and power plants. The mean concentration of Aitken nuclei near the laboratory was measured at  $45,000 \text{ particles cm}^{-3}$ .

At the collection site on the arctic seacoast about 3 km northeast of the laboratory, the measurements of Aitken nuclei ranged from 50 to 300 particles  $\text{cm}^{-3}$  in the maritime air. The mean concentration was  $100 \text{ particles cm}^{-3}$ .

#### Aerosol observations and analyses

Aerosols in maritime air from the Arctic Ocean were collected on electron microscope grids covered with collodion film. The volume of maritime air sampled was measured, as was the collection efficiency of aerosol particles on the filmed grids (Langmuir and Blodgett 1946, Kumai and Francis 1962). The aerosol samples for electron microscopy were kept in a dessicator and brought back to CRREL. The specimens were shadowed with chromium vapor at an angle of  $23.5^\circ$  by a conventional shadowing technique and examined by transmission

electron microscopy and electron diffraction analysis.

The diameter of each aerosol particle was measured from the electron photomicrographs and found to be from  $0.01$  to  $2.5 \mu\text{m}$ . The most frequently observed diameter in the samples was  $0.04 \mu\text{m}$ . The mean size distribution of aerosols in the maritime air is shown in Figure 2.

Concentrations of aerosols were calculated, considering the collection efficiencies, from the aerosol numbers in a known sample volume of air. Concentrations of three samples were calculated to be 101, 84, and 76 particles  $\text{cm}^{-3}$ ; thus the mean was  $87 \text{ particles cm}^{-3}$ .

Typical transmission electron micrographs of aerosol particles in maritime air collected near Barrow, Alaska, are shown in Figure 3 and on the cover. The semi-hexagonal particle in Figure 3a was identified as a clay mineral from its hexagonal net pattern (Fig. 3b) taken by the selected area electron diffraction method. The aerosol particle in Figure 3c was identified as a sea salt particle primarily composed of NaCl and a trace of KCl. The aerosols in Figure 3d were identified as coagulated carbon particles, a solid combustion by-product.



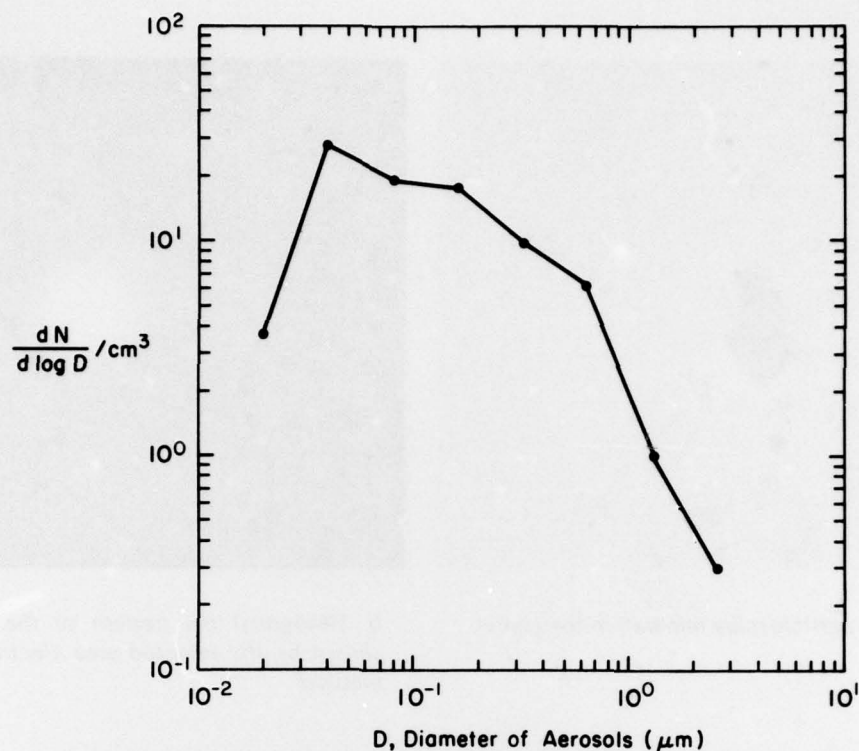


Figure 2. Mean size distribution of aerosols in maritime air collected at the pack ice covered arctic seacoast near Barrow, Alaska, during June 1975.

Table I. Concentration and identification of aerosol particles collected near Barrow, Alaska, using electron microscopy and electron diffraction analysis.

Materials	Concentration of particles (cm <sup>-3</sup> )	Diameter range (μm)
Sea-salt particles	2	0.8 -1.3
Clay particles	3	0.2 -2.5
Combustion by-products		
Carbon particles	15	0.06-0.8
Flyash	1	0.03
Unidentified minute particles	80	0.01-0.3
Total	101	0.01-2.5

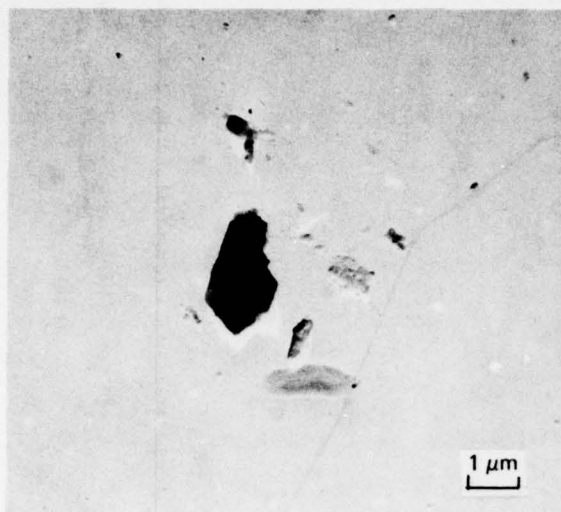
Table I gives the concentration, particle diameter range, and identification of aerosols collected near Barrow. The total concentration was 101 particles cm<sup>-3</sup>. The aerosol particles were identified from their morphology and the results of electron diffraction analysis. Sea salt aerosols, as seen in Figure 3c, were found to comprise 2 particles cm<sup>-3</sup>. Carbon aerosols (Fig.

3d) contributed 15 particles cm<sup>-3</sup>, and the flyash concentration (Kumai 1966) was 1 particle cm<sup>-3</sup>. Many aerosols (80 particles cm<sup>-3</sup>) were found to be too small to identify by these methods.

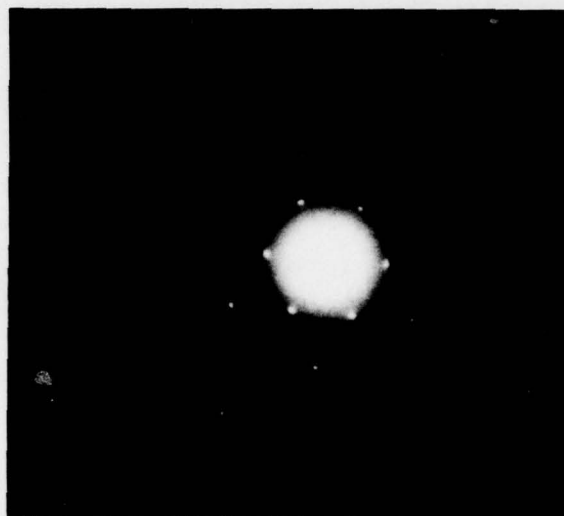
Measurements of concentrations of sea-salt particles (sodium-content particles) in maritime air by several workers are shown in Table II. In the measurements made in this study, the mean concentration of sea-salt particles was 2.0 particles cm<sup>-3</sup>. The sea-salt particle concentration found near Barrow in March 1970 by Radke et al. (1976) varied from 0.79 to 1.62 particles cm<sup>-3</sup>, and averaged 1.2 particles cm<sup>-3</sup>. Radke (1969) found the concentration of sodium-containing particles to be 2.5 cm<sup>-3</sup> at an altitude of 150 m with breaking waves at the Strait of Juan de Fuca off Port Angeles, Washington.

## SUMMARY AND CONCLUSION

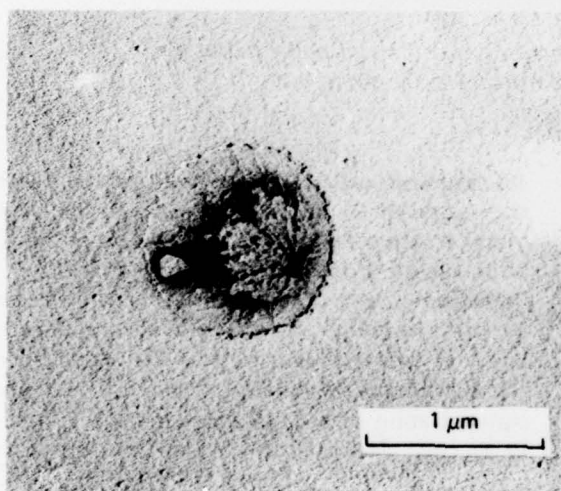
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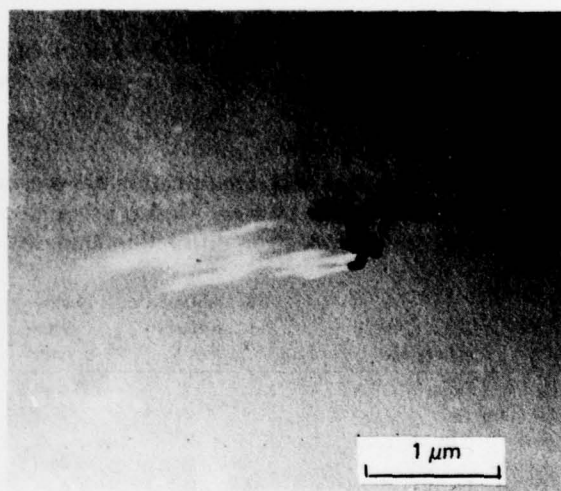
*a. Hexagonal particle (clay mineral) in the center.*



*b. Hexagonal net pattern of the clay mineral shown by the selected area electron diffraction method.*



*c. Sea-salt particle.*



*d. Carbon particles coagulated from solid combustion by-product.*

**Figure 3.** Electron photomicrographs of aerosol particles in maritime air collected at the arctic seacoast near Barrow, Alaska.

Table II. Comparison of measurements of concentration of sea-salt particles in maritime air.

Location	Date	Concentration of sea-salt particles ( $\text{cm}^{-3}$ )	Comments	Reference
Strait of Juan de Fuca off Port Angeles, Washington	7 Nov 1968	2.5	At an altitude of 150 m with breaking wave in westerly wind	Radke (1969)
Near Barrow, Alaska	15 Mar 1970	1.2	Air flow shifted from east to northwest	Radke et al. (1976)
Near Barrow, Alaska	18 Mar 1970	0.79	Northwesterly wind, changed to north- erly	Radke et al. (1976)
Near Barrow, Alaska	24 Mar 1970	1.62	Northeasterly wind	Radke et al. (1976)
Near Barrow, Alaska	11 Jun 1975	2.0	Northwesterly wind	This paper

varied from 50 to 300 particles  $\text{cm}^{-3}$ , depending upon meteorological conditions. The mean concentration of Aitken nuclei counted was 100 particles  $\text{cm}^{-3}$ . The diameter of Aitken nuclei was estimated to be over  $2 \times 10^{-3} \mu\text{m}$ .

2. Transmission electron micrographs were taken of the aerosols collected on the electron microscope grids covered with collodion film. The concentrations were measured to be 76 to 101 particles  $\text{cm}^{-3}$ . The mean concentration was calculated to be 87 particles  $\text{cm}^{-3}$ . The size range was measured to be from 0.01 to  $2.5 \mu\text{m}$  in diameter. The most frequently observed diameter was  $0.04 \mu\text{m}$  in the samples. Since the efficiency of grid collection is very low for particles of less than  $0.01 \mu\text{m}$  diameter, it is considered that the probable mean concentration of aerosols between  $2 \times 10^{-3}$  and  $10^{-2} \mu\text{m}$  diameter was 13 particles  $\text{cm}^{-3}$ . This estimate is based on the difference between the mean Aitken nuclei count and the mean concentration of aerosols collected on grids and measured by electron photomicrographs.

3. In these field and laboratory experiments, the mean concentration of sea-salt particles was 2.0 particles  $\text{cm}^{-3}$  in June of 1975. But the mean concentration of sodium-containing particles in March of 1970 was 1.2 particles  $\text{cm}^{-3}$  (Radke et al. 1976). It is concluded that the concentration was slightly increased in the summer season compared to the late winter season because of the increase in open sea area in the Arctic Ocean.

4. About 20% of the aerosols in maritime air from the Arctic Ocean were identified by transmission electron microscopy and electron diffraction analyses. About 80% of the aerosols were too small for electron diffraction analyses.

Sea-salt particles (Fig. 3c) composed 2% of the total number of particles, and clay particles (Fig. 3a) 3%. These particles were considered to be of natural origin. Solid combustion by-products such as carbon particles (Fig. 3d) and flyash (Kumai 1966) were found to constitute 16% of the particle total. The origin of solid combustion by-products was considered to be caused by human activities. In the identified aerosols, natural aerosols were of lower concentration than those produced by human activities.

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